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US Army Corps
of Engineers
Sacramento District

Initial Appraisal
Sacramento River
Flood Control Project
(Glenn-Colusa), California

February 1989

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INITIAL APPRAISAL

SACRAMENTO RIVER FLOOD CONTROL PROJECT (GLENN-COLUSA), CA

10 FEBRUARY 1989

Sacramento District
Corps of Engineers
650 Capital Mall
Sacramento, CA 95814

EXECUTIVE SUMMARY

The Sacramento River floods of 1969-70 led to degradation of the riverbed at the head of the Glenn-Colusa Irrigation District (GCID) intake channel. The elevation of the riverbed has dropped about 3 feet, causing problems with operation of their fish screens, intake channel, and pumps. The proposed GCID project will restore the river gradient to its pre-1970 level, improve fish screen operations, and improve intake channel conditions. Project alternatives consider rehabilitating existing facilities, constructing new facilities at the existing site, and constructing new facilities at new sites. GCID has submitted a project report for Corps review and analysis. The GCID Report advocates 3 project alternatives, each including a gradient restoration feature of 5 sheet-pile weirs. The Corps was asked to participate in the gradient restoration feature only.

USACE interest in the Sacramento River is demonstrated by (1) the Sections 10 and 404 permitting process, including GCID's interim permit, (2) authorized flood control projects, and (3) an authorized navigation project. These authorized projects include:

Flood Control

- o Sacramento River Flood Control Project
- o Sacramento River, Chico Landing to Red Bluff Project
- o Sacramento River Bank Protection Project
- o Sacramento River and Major and Minor Tributaries

Navigation

- o Sacramento River, Shallow Draft Channel.

Further, potential USACE interest is demonstrated by Sections 1135(b), as amended, and 704(b) of the Water Resources Development Act of 1986 (WRDA 86), and possibly other authorities and programs. Potential USACE authorities are summarized below.

- o Section 1135(b) of WRDA 86, as amended, on the basis that the gradient restoration feature is a modification of an existing project (Sacramento River, Chico Landing to Red Bluff Project) to improve the quality of the environment in the public interest through fish and wildlife enhancement. However, a previous SPK application was denied,and Congress has continually refused to fund this type of project.
- o Section 704(b) of WRDA 86 on the basis that the project is a beneficial modification of habitat for fish and wildlife. However, current Corps policy views this as a one-time authorization for four projects listed in WRDA 86.
- o Add a project purpose for fish and wildlife enhancement to an existing project. However, a two-fold policy decision would be required, including determination of enhancement as opposed to mitigation, and determination of approproateness of action.

In conclusion, USACE interest in the GCID gradient restoration project is in the Sections 10 and 404 permitting process, including GCID's current interim permit.

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INTRODUCTION

This report is an appraisal of the Glenn-Colusa Irrigation District (GCID) study and report entitled, "Feasibility Report GCID/DF&G Fish Protection and Gradient Control Facilities," prepared by GCID, Department of Fish and Game (DF&G), and CH2M Hill, received December 14, 1988. Included in this initial appraisal is a background and summary of the GCID Report, followed by the Corps of Engineers Sacramento District technical review and analysis, which includes a discussion of the basis for USACE interest.

The floods of 1969-70 led to degradation of the Sacramento River streambed at the head of the GCID intake channel. GCID completed construction of their fish screens in 1972. The impact of the streambed drgradation was not evident until approximately 1982 due to its upstream progression from several miles downstream of the intake channel. The proposed GCID project includes restoring the streambed gradient and improving fish screen and pumping efficiency. The Corps has been asked to consider participation in only the streambed restoration feature of the total project. GCID and the State of California are willing to cost share this portion of the project. GCID believes that restoration of the Sacramento River gradient to its pre-1970 level can best be accomplished by the Corps of Engineers, which has authority for constructing bank protection and other flood protection measures in this reach of the Sacramento River.

BACKGROUND AND SUMMARY OF GCID REPORT

This first portion of the Initial Appraisal is a background and summary of the GCID Report. It is provided as information for those who may not have copies of the GCID Report. As a summary of the GCID report, the section below reflects their views and beliefs, and does not necessarily represent the Corps position or policy. The Sacramento District technical review and analysis of the GCID Report follows the GCID summary and begins on page 20.

BACKGROUND

The Glenn-Colusa Irrigation District (GCID) is located in the central portion of the Sacramento Valley about 100 miles north of Sacramento, on the west side of the Sacramento River. District boundaries extend from northeastern Glenn County near Hamilton City in the north, to below Williams in Colusa County, in the south (see Figure 1). GCID supplies water to 175,000 acres of farmland, including nearly 25,000 acres at three Federal wildlife refuges. The principal water supply for GCID comes from the Sacramento River, with a limited supplemental diversion from

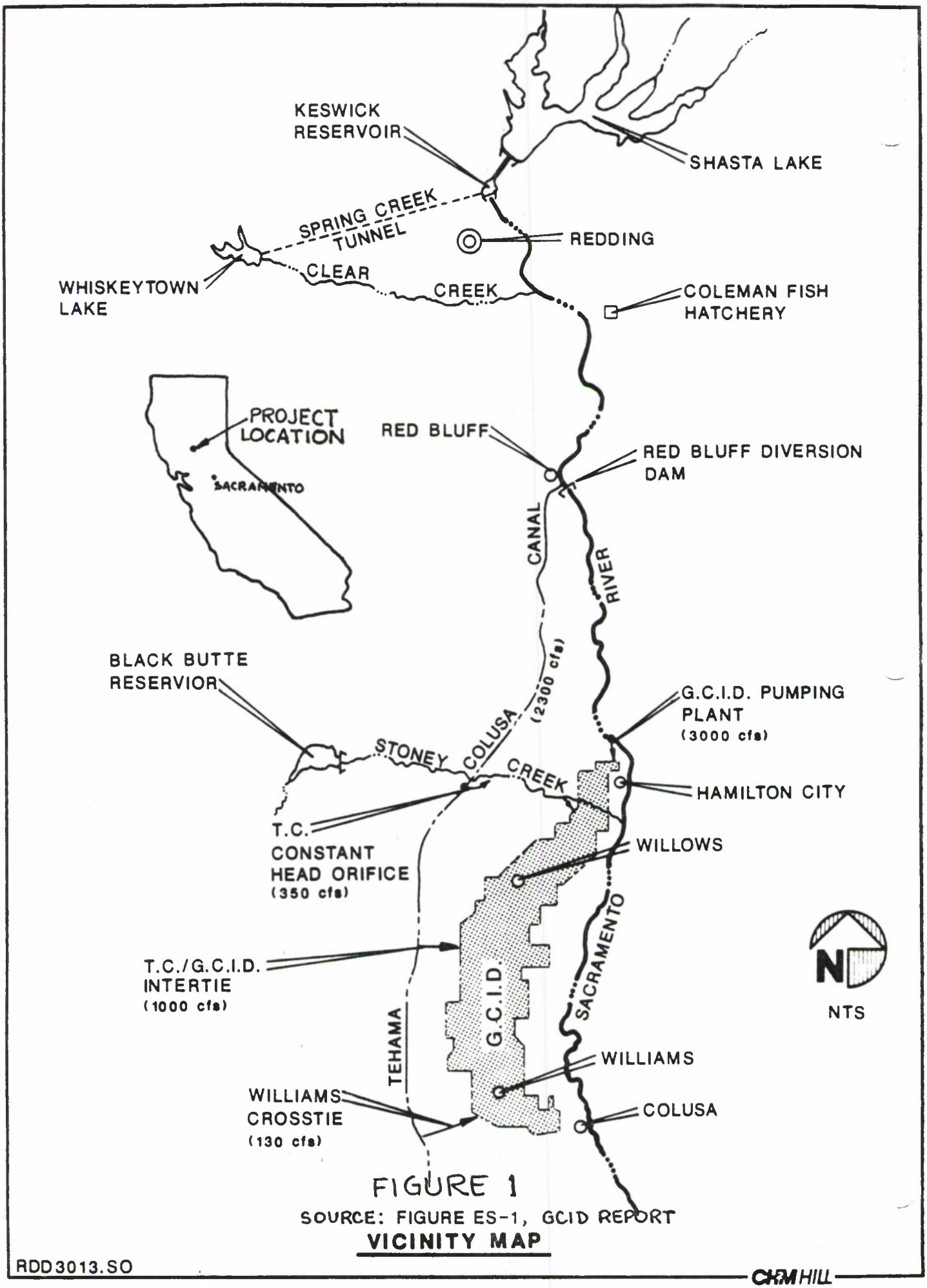

FIGURE 1

SOURCE: FIGURE ES-1, GCID REPORT

VICINITY MAP

RDD3013.SO

CH2MHILL

FIGURE 1

Stony Creek during parts of the irrigation season. GCID also routes water from the U.S. Bureau of Reclamation's (USBR) Central Valley Project.

GCID's intake channel on the Sacramento River is on the outside bend of a natural meander channel in the vicinity of River Mile (RM) 206 (see Figure 2). Periodic maintenance dredging of the intake channel between the pump station and the main river has been an essential part of GCID's operations since diversions began in 1905. During the past 6 years, annual dredging has been required to remove material deposited at the head of the intake channel. The dredging helps maintain an adequate intake channel depth and provides maximum water-surface elevation to the fish screens and pump station during periods of peak irrigation demand. The fish screen at GCID was one of the largest in the world at the time it was constructed in 1972 by California Department of Fish and Game (DF&G) at a cost of $2.6 million. The screens consist of a 475-foot-long concrete abutment housing 40 bays. Each bay contains a single, rotating, 17-foot diameter by 8-foot-wide drum covered with stainless steel mesh cloth. The drums rotate on a horizontal axis as the water flows through the screens.

PROBLEMS

Changes in the river morphology -- bend cutoffs, scour, deposition, bar formation, and shoaling -- directly affect the GCID pumping facility and screens. In January 1970, the bend just downstream of the GCID facility at RM 205, cut off. This caused a 9,000-foot reduction in channel length, thus increasing the stream hydraulic slope and the erosion of the riverbed. This degradation and flattening of the river invert gradually moved upstream to the vicinity of the GCID intake channel, from RM 205 to RM 207. Flows since that time have continued degradation of the river gradient. The elevation of the river channel at the mouth of the GCID intake channel dropped about 3 feet from pre-1970 conditions, causing an increased lift at the pump station.

Of much greater concern, however, is the impact of the change in river gradient on the efficiency of the fish screens. Four runs of Chinook salmon - fall, late fall, winter, and spring - spawn above the GCID point of diversion. Each run is a genetically distinct race. In addition, steelhead trout run in the late fall. Although it is estimated that the fall salmon run approximates 90 percent of the total salmon run, the much smaller winter run is being considered for listing as a threatened or endangered species by the State of California.

The reduced water surface on the fish screens has resulted in lower water levels and faster through-screen velocities than those used for design. This results in significant losses to the anadromous juvenile downstream migrants from natural spawning, and to a lesser degree, from fish at the U. S. Fish and Wildlife

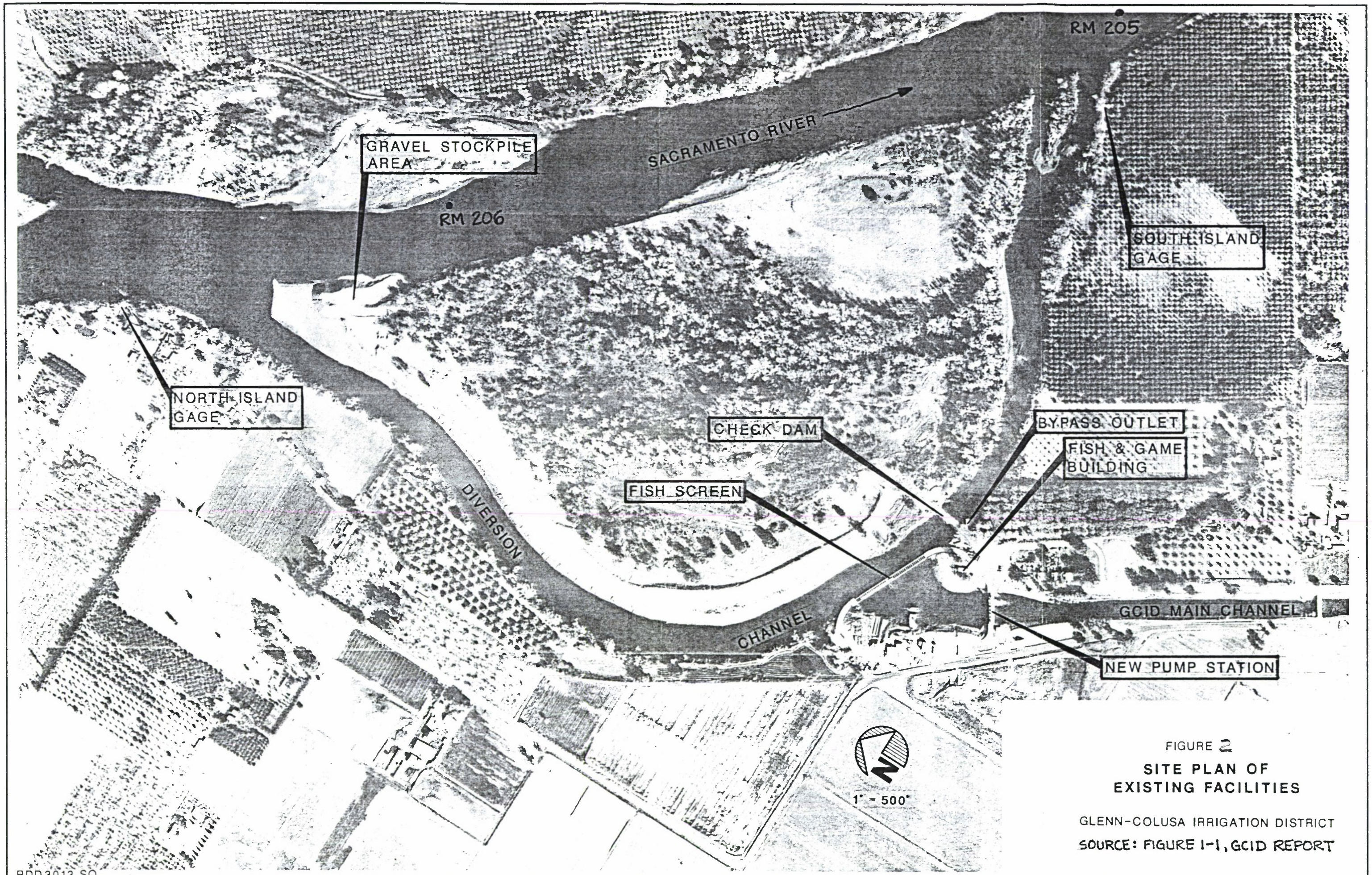

FIGURE 2

SITE PLAN OF EXISTING FACILITIES

GLENN-COLUSA IRRIGATION DISTRICT

SOURCE: FIGURE 1-1, GCID REPORT

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CH2M HILL

FIGURE 2

Service's Coleman Fish Hatchery. In addition, river degradation compounds fish losses due to the reduced flows in the return channel past the screens and back to the main river. Low flows and velocities in the return channel promote conditions which attract predatory fish that prey on the juvenile fish attempting to return to the main river. These losses are estimated by DF&G to be as much as 6.5 million fish annually.

Because of the river degradation, increased maintenance dredging has been necessary in recent years to improve the screen bypass flows. In granting an interim Section 404 permit for the dredging, the Sacramento District, Corps of Engineers (Corps) imposed specific operating conditions and required GCID to develop a long-term solution to ensure water supply and fishery resource protection. There has been significant public interest in the permit process. The Corps' interim permit expires in December 1989, and GCID is required to submit a report to the Corps by November 15, 1989, together with an application for a Department of the Army Permit, to implement the fishery protection measures that must be initiated in 1990.

PLAN FORMULATION

In 1984, the GCID and DF&G recognized the degradation of the river as a major threat to the pumping and fish screen operations. Discussions and meetings of those agencies' representatives resulted in a Memorandum of Understanding (MOU), adopting a jointly funded study plan. The study would address the river mechanics, review design of the existing fish screens, and identify and select a design for the long-term solution to the interrelated problems of water supply and fish protection. The MOU also established an Advisory Committee to develop and refine design criteria for the fish screens and to develop alternative solutions. In addition, the Corps of Engineers' interim permit established a Technical Advisory Group consisting of representatives of Federal and State agencies and conservation groups provides comments on these studies.

Fish screen criteria were reviewed for this specific reach of the Sacramento River. The hydraulic characteristics of the river were analyzed, and geomorphology investigations were conducted to determine the future stability of the river gradient. Alternative solutions were identified, ranging from major relocation of the fish screens and/or intake channel to the "no action" alternative. These alternatives were evaluated for applicability and effectiveness in resolving the problems. The alternative solutions that were physically and biologically viable were further analyzed, with costs and relative benefits calculated.

It was determined that all feasible fish screening alternatives/modifications would require restoration of the river hydraulic gradient to the pre-1970 conditions. As a result, the assistance of the Corps of Engineers and the State of California

was sought because of their authorized programs for this reach of the river. In 1988, the House Committee Report included language directing the Corps to initiate preconstruction engineering and design to determine the best method for restoring the river gradient at this site; Congress included $360,000 in the Fiscal Year 1989 appropriations for this purpose (H.R. 100-724). The appropriation did not include funds to design any of the fish screen facilities, or to modify the pumping facilities.

The project benefits were examined both for the total project and for the hydraulic gradient restoration component alone. The most important benefits from the gradient restoration would be assurances of flow to the irrigators and protection of the fishery. The GCID report identified additional important benefits that relate to water delivery, water supply, pumping, sediment/erosion control, and intake channel dredging. Flood control and water management benefits were identified but not quantified.

PROJECT BENEFITS

Potential project benefit categories are discussed in detail in the GCID report, and are summarized here.

Fishery Benefits

Numerous variables affect the project fishery benefits: annual fish loss, predicted predation loss in the intake channel and at the screens, economic value of a fish and method of determining that value, species of fish being protected, size of fish, and others. The methods of estimating each of these variables in relationship to the benefits are highly subjective. The annual fish losses at the screens vary from year to year depending on the flow in the river, the timing of the fish out migrations with regards to GCID diversions, GCID diversion adjustments to reduce fish impacts when possible, and ability of GCID to dredge material from the mouth of the intake channel. The species of fish is also important. For example, the winter-run Chinook salmon from the Sacramento River is presently undergoing review under the Endangered Species Act. It is a special status strain, and all regulatory agencies give its protection highest priority.

The project fishery benefit was estimated by two methods: (1) value of a commercially harvested fish at $58 per fish, and (2) value of a spawner at $106 per fish. The fishery benefits derived by each method are shown in Table 1.

Table 1

PROJECT FISHERY BENEFIT ESTIMATE

o	Estimated fish harvested by commercial industry	47,600
o	Estimated escapement (spawners and river sport)	22,400
o	Estimated increase in adult fish	70,000
o	Value of fishery enhancement based on commercial benefit method ($58 per fish x 47,600 fish)	$2,760,800
o	Value of fishery enhancement based on value of a spawner ($106 per spawner for "enhancement of stock" x 22,400 fish)	$2,374,400

Source: Table 4-9 of GCID report

The gradient restoration component of the project would provide fishery benefits, in combination with the existing screens. This in-river elevation control structure would correct the adverse degraded elevations so that the screen would operate at its original design elevation. The existing screens would afford protection to the larger fry, but would still be ineffective for fry less than 50 mm in length. The smaller the fry, the weaker their swimming ability, and the more vulnerable they would be to entrainment, impingement, and predation. Also, the gradient restoration would create a channel bypass flow from the screens back to the river. The high bypass flow will reduce predation. CH2M Hill biologists estimate, based on observations at the screens during the "Coleman Hatchery fish flush", in May 1988, that fish losses may be decreased by up to 90 percent for the larger size fry by simply installing the gradient restoration structure. According to DF&G, up to 6,500,000 juvenile fish pass through the intake channel each year, and 84-95 percent of these fish could be saved with the new features. This translates to 5,460,000 fish that could be saved. Approximately 1.3 percent would survive to adulthood, which would provide an additional 70,000 adult salmon returning as a result of the project. For purposes of their analysis, the GCID report estimated that the gradient restoration, in combination with the existing screens (with some minor modifications), will reduce the fish losses from 50 to 90 percent depending on the other aforementioned variables. A conservative estimate of enhancement of 50 percent of the lower value was assumed, resulting in an annual fishery benefit of $1,187,000.

Water Delivery Benefits

Water delivery benefits would be developed from the assurance that with the river gradient restored and stabilized, the need for supplemental supplies would be eliminated. As a result, the potential for requiring supplemental water during reverse flow conditions or during the Coleman fish hatchery flush by rerouting water through the Tehama-Colusa Canal system, would be avoided. The cost of this additional water, estimated by GCID to be about 30,000 acre-feet at $1.50 per acre-foot, is $45,000 per year. This is today's U.S. Bureau of Reclamation wheeling charge to convey GCID water through the Tehama-Colusa Canal and is subject to future change.

Water Supply Benefits

The water supply benefits were based on the assumption of continued river gradient deterioration. Should the river gradient fall another 1.0 feet, the GCID pump station would need to reduce the intake flows to about 2,300 cfs in order to avoid reverse flows in the return channel, pump damage, and critical intake/bypass fishery problems. This occurrence would translate into a need for other water supplies for about 100 days during an average delivery year. Assuming an average delivery rate during the 100-day period of 2,600 cfs, the incremental water supply would need to be approximately 59,500 acre-feet per year. Using a conservatively low estimate of the value of water at $15 per acre-foot to develop and deliver this additional supply, the project benefit for water supply becomes $892,500 per year.

Pumping Benefits

Following the river gradient restoration, the GCID pump station system would typically operate at a 2-foot higher forebay elevation than under existing conditions. The increase in forebay elevation would reduce lift and the pump energy requirements. GCID records were used to estimate average demand and lift requirements on a monthly basis. These data, along with power charges, were used to determine an estimate of the power benefits. The savings obtained from reducing the power costs were estimated at approximately $77,400 per annum in 1988 dollars.

Sediment/Erosion Control

The sheet-pile weirs of the gradient restoration structure will extend through an existing sand bar to the east bank, stabilizing this bar at its present location. This point bar contains 340,000 cubic yards (cy) of armored (surface) and subarmor sediments, of which approximately 50 percent is 20 mm grain size or smaller. The GCID report assumed that without the

project, this smaller material would be transported to downstream flood control and navigation channels, which are dredged periodically.

The gradient restoration structure will result in an 0.5 foot aggradation of the river bottom in the 2-mile reach immediately upstream of the structure. This aggradation will amount to approximately 78,000 cubic yards of sediment. It was assumed 50 percent of this sediment would otherwise result in additional downstream dredging.

The GCID report concludes that this project will reduce the downstream sediment transfer of 209,000 cubic yards of fine materials. Assuming a removal cost of $3/cy, the erosion control benefit will approximate $12,500/year. The benefit was spread uniformly through the life of the project, although in reality, higher annual benefits would be received in the near term.

Intake Channel Dredging

The GCID is annually dredging 40,000 cy of additional sediment in their intake channel since the last major loss of river gradient in 1983. The GCID report estimates it costs them approximately $100,000/year (@ $2.50/cy) more to dredge today than prior to 1983.

It is assumed that of this dredged material, approximately 50 percent of it would find its way to navigation channels and need to be dredged by others. Assuming a dredging cost of $3.00/cy by others, the benefit received by the GCID will result in a cost of $60,000 to others (40,000 cy x 50 percent x $3.00/cy). Thus, the net benefit to the reduction in dredging is approximately $40,000/year.

ALTERNATIVES DESCRIPTION

The GCID Report describes 10 alternatives developed throughout the course of the planning process. It lists the advantages and disadvantages of each from both biological and engineering perspectives. The alternatives were rated qualitatively, e.g., good, average, poor, etc. These ratings were then translated into numerical scales of merit to develop a merit versus cost rating system.

The three best alternatives are recommended for further design development in the GCID Report, and are described below. All three require the hydraulic gradient restoration. Alternative A consists of rehabilitating the existing screen house and bypass or constructing a new screen facility and bypass near the existing site. Alternative B1 involves construction of a new screening facility in the upper end of the existing

diversion channel closer to the river. Alternative C proposes construction of a new vertical fixed screen approximately 1,200 feet long at RM 207.

Hydraulic Gradient Restoration Features of Alternative A,B1,and C

Artificial hydraulic gradient restoration is an important component of all alternatives. Many of the following approaches have their own advantages and disadvantages relating to materials, stability, and construction practices. At this time, the use of sheet-pile weirs has been assumed for inclusion into each of the screen-site location alternatives.

A single barrier for raising the channel bottom sufficiently to restore the water-surface profile (gradient) was believed to have substantial deleterious effects on the river and environment because of rapid changes in velocity at one location. Additionally, a single barrier gate or dam configuration could impede navigation and possible upstream fish migration. As a result, consideration of a single barrier such as an inflatable dam and bascule gates was not considered further.

The channel constriction methods for gradient restoration such as groins or palisades were believed to have the potential to cause significant erosion due to the velocities in the main channel. Under low-flow conditions, the sides of the channel would essentially be forced well into the river to raise the upstream water surface elevation. As a result, the mid-channel velocity would increase, presenting a high erosion potential. Due to the concerns with additional channel scour and transport of sediment downstream, palisades and groins were not considered further in this study.

The subalternative of using dredged material to elevate the stream channel was ruled out because of environmental sensitivity associated with placing of the gravel in the river and, if placed, holding the material in place. In addition, the Corps may not allow these materials to be placed in the river, particularly in the spring when many juvenile salmon are in the river.

The remaining artificial gradient restoration methods were rock/rubble barrier(s), gabions, concrete, and sheet piling. Each of these methods may include combinations of different materials. An example might be sheet piling used to anchor gabions and rubble, or gabions and concrete used conjunctively across the river. The material composition was not as critical at this conceptual level as the preferred stepwise increase of the channel invert to spread the velocity changes over several hundreds of feet. This approach would permit a smoother transition of velocities for the migrant salmon in both upstream and downstream directions, as well as reduce the erosion potential and allow easy navigation. Because each of the remaining methods for achieving the river gradient restoration

were similar except for materials and placement, the differences would be limited to cost. To simplify the alternative comparison effort, the use of sheet piles was selected for cost estimating purposes. This gradient restoration feature of all three proposed alternatives is shown in Figure 3. Regardless of the chosen gradient restoration method, some bank stability and bank protection measures will be required.

Alternative A -- modify existing fish screen or construct new fish screen near the existing facilities - and gradient restoration feature

Alternative A, as shown in Figure 4, was developed to maximize use of the existing facilities. It appears that some screen configuration could be successfully operated at this location when coupled with improved river gradients and a modified bypass system.

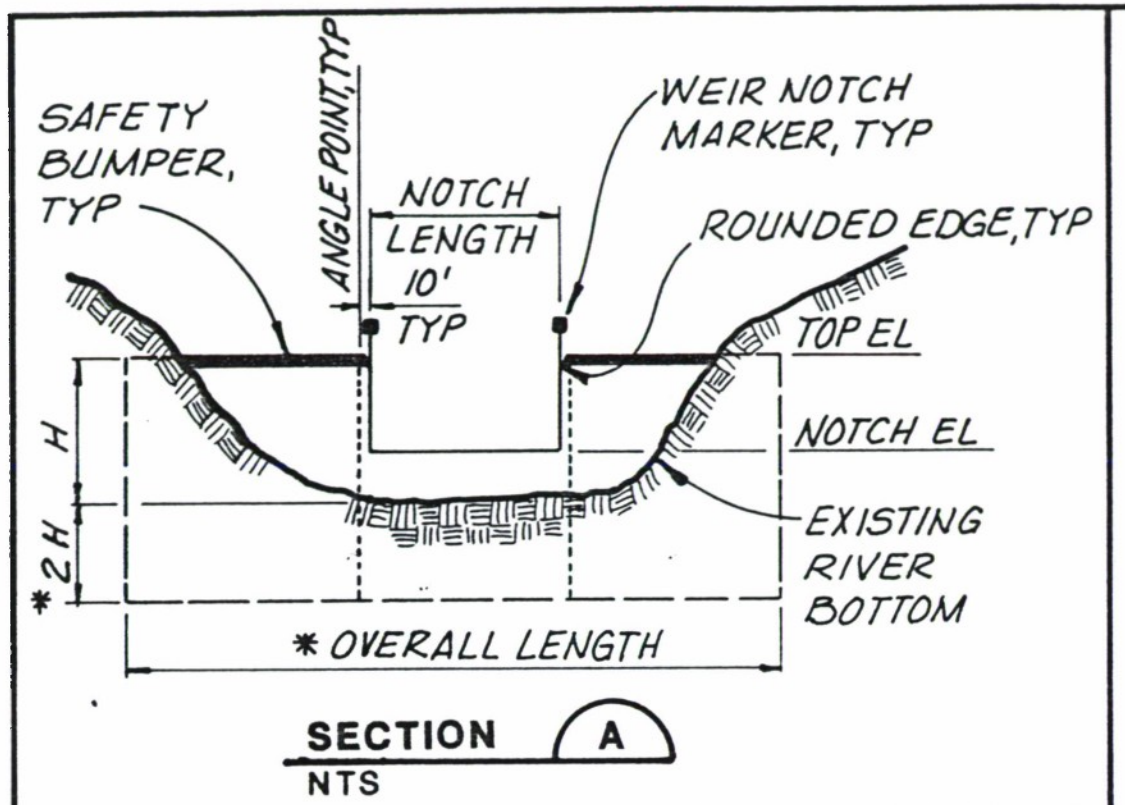
The facilities proposed for this alternative would include modifications to the existing screening structure and/or the construction of new screening facilities, possible construction of a control structure downstream of the existing screens, improvements to the downstream diversion channel or a new piped bypass system, and restoration of the river gradient to pre-1970 levels.

The existing site with river gradient improvements is technically indexed as an average-to-good alternative for the fisheries and good from an engineering standpoint. Its fishery benefits with relation to new or rehabilitative construction are clouded because of the need to continue using the intake channel with some remaining concern about predation. With a clean hydraulic profile, a minimum average velocity of 2 fps, and high relative bypass flow, fishery biologists feel that predation potential will be significantly lowered from past conditions and approximate that which exists in the main river. The limited effects on the river morphology help offset the construction location/operational constraints.

Alternative B1 -- relocate fish screen near head of existing diversion channel, RM 206 - and gradient restoration feature

This alternative, shown in Figure 5, would relocate the fish screens to near the head of the existing west channel. This location would place the screens near the edge of the river and would include a direct bypass system back to the river at a point near the last weir.

The proposed facilities would include new fish screening facilities, new bypass facilities, a river gradient structure necessary to maintain river elevations, bank slope protection upstream and downstream of the present diversion point, and two small diversion structures for elevation control across the existing west channel immediately downstream of the new facility



SOURCE: FIGURE 3-1, GCID REPORT

SHEET PILE SCHEDULE
(ALL VALUES ARE APPROXIMATE)

PILE Nº	NOTCH LENGTH	OVERALL LENGTH	TOP EL	NOTCH EL	H
(1)	180'	1,100'	136.6	130.8	5.8'
(2)	180'	725'	137.3	131.6	6.5'
(3)	180'	675'	138.1	132.3	7.3'
(4)	180'	700'	138.8	133.1	7.9'
(5)	180'	1,150'	139.6	133.8	8.7'

FIGURE 3
SITE PLAN
PROPOSED GRADIENT WEIRS FOR WATER SURFACE RESTORATION
GLENN-COLUSA IRRIGATION DISTRICT
CH2M HILL

RDD 3013.SO

FIGURE 3

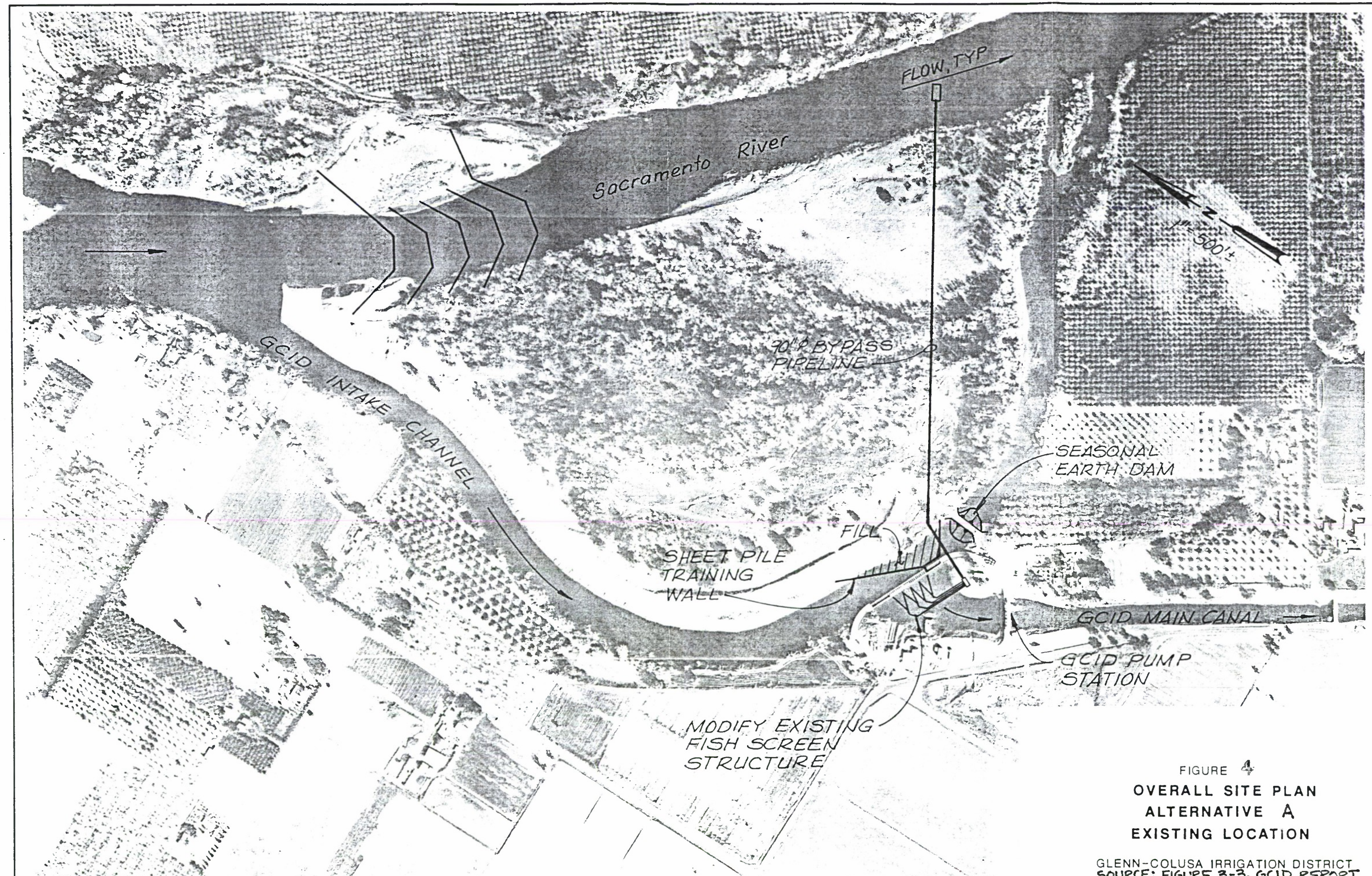


FIGURE 4

OVERALL SITE PLAN
ALTERNATIVE A
EXISTING LOCATION

GLENN-COLUSA IRRIGATION DISTRICT
SOURCE: FIGURE 3-3, GCID REPORT

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FIGURE 4

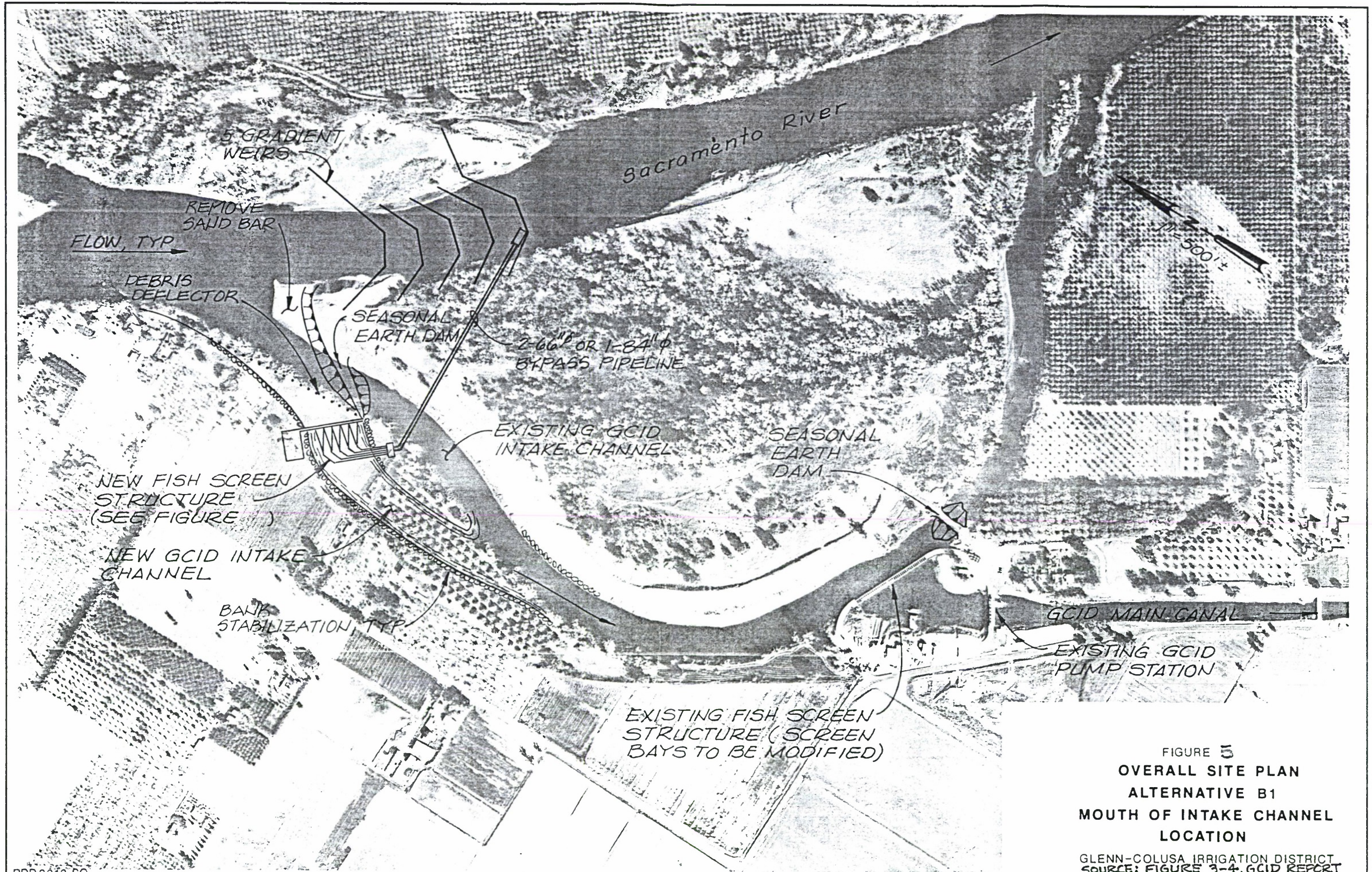

FIGURE 5
OVERALL SITE PLAN
ALTERNATIVE B1
MOUTH OF INTAKE CHANNEL LOCATION

GLENN-COLUSA IRRIGATION DISTRICT
SOURCE: FIGURE 3-4, GCID REPORT

CH2M HILL

FIGURE 5

and just below the existing fish screening facility. These small dams would be removed during the non-irrigation season to permit flood flow through the west channel. During the irrigation season, all diversion flows would pass through the new facility.

The artificial gradient restoration would also be required to restore the river gradient to pre-1970 levels and to continue use of this reach of the river for boat passage.

The alternative of moving the fish screen facility to near the head of the existing channel is rated as good for fisheries and average-to-good from an engineering standpoint because of the uncertainties associated with the river equilibrium under existing conditions and the known deposition problems. A new fish screen facility would permit incorporation of advanced screen technology, as with the other alternatives, but this can only be useful if the river hydraulics and regime can be stabilized at or near the entrance.

Alternative C -- relocate diversion and fish screen to upstream bend at RM 207 - and gradient restoration feature

The relocation of the GCID diversion intake and fish screens upstream of the next bend in the river at RM 207 is shown in Figure 6. The idea was to find a position in the river from which to divert water and to place new screens that would exhibit better morphological characteristics. The west bank formation at this site is stable due to direct contact with the Riverbank Formation as stated by Water Engineering and Technology (WET). The diversion would be located on the outside of the bend, which would normally be advantageous for velocity. However, the possibility exists of a bend cutoff at RM 207 according to the present cutoff index described by WET. Substantial bank protection and stabilization, both upstream and downstream of this site, will be necessary to stabilize the bends of this reach to avoid cutoff. The forces created by flooding at this site can be extreme.

The proposed facilities would include a new vertical fixed-screen facility, a new diversion canal from the diversion point at or near the forebay of the existing GCID pump station, a river gradient structure to maintain a minimum river elevation, and bank slope protection upstream and downstream of the point of diversion to stabilize the riverbanks and bend.

Alternative C is rated as poor-to-average from an engineering standpoint because of the significant uncertainty surrounding the river morphology at this bend. Although there are definite fish screen-related theoretical advantages, such as keeping the fish in the main river, there is no experience with a 1200 feet-long-screen. The likelihood of the new fish screen facility operating as planned cannot be disassociated from design constraints imposed by the uncertainties with the natural river. The costs for positively controlling these hydraulic variables

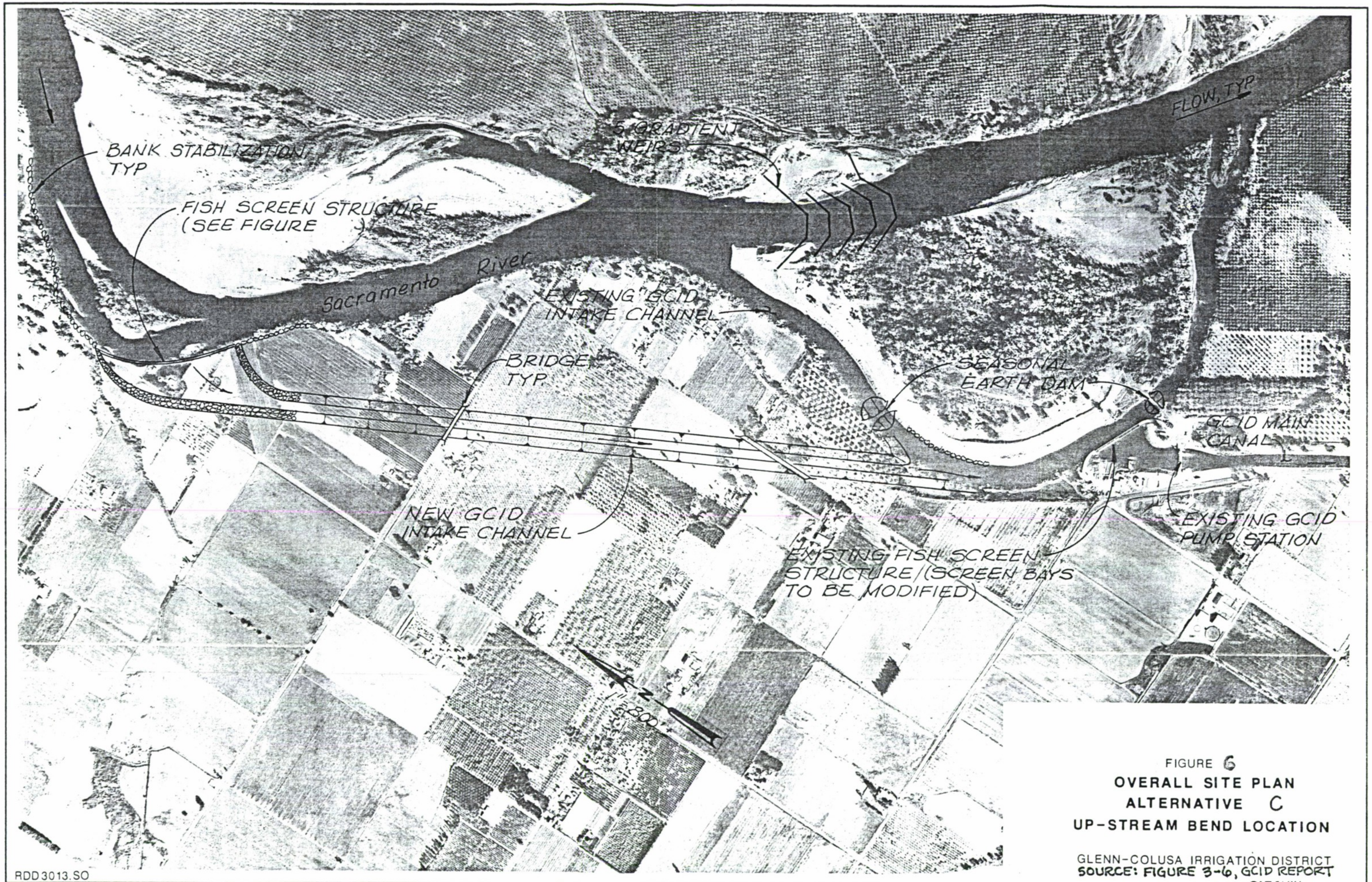

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FIGURE 6
OVERALL SITE PLAN
ALTERNATIVE C
UP-STREAM BEND LOCATION

GLENN-COLUSA IRRIGATION DISTRICT
SOURCE: FIGURE 3-6, GCID REPORT

CH2M HILL

will be high and must be studied in detail. Regardless, this alternative is judged as good for fisheries issues assuming the river can be maintained on the west bank.

BENEFIT-TO-COST RATIOS

The benefits and costs of each alternative are given in the GCID report in 1988 dollars. No effort was made to estimate the future value of fish, power, water, or other economic components. The annualized capital costs are based on an interest rate of 8-5/8 percent and a project life of 50 years. The capital costs, annual O&M costs, and costs and benefits for Alternatives A, B1, C, and the gradient restoration component of these alternatives are shown in Table 2 (GCID report Table 4-10).

CONCLUSIONS IN GCID REPORT

The GCID report concludes that:

- There are viable ways to significantly improve fish protection at the GCID intake, each of which requires a Federal/local agency partnership project.
- All alternative fish screen modifications/replacements require restoration and stabilization of the river and support by all participating agencies is unanimous.
- The restoration of the river hydraulics can be accomplished by a variety of feasible methods including the plan contained in this report consisting of a series of sheet-pile weir sections across the river channel.
- Three alternatives for fish screen facilities will provide acceptable fish protection, the costs of which are summarized as follows:

	Capital Cost[a]	B/C Ratio
Alternative A	$21,300,000	1.7:1
Alternative B1	30,000,000	1.3:1
Alternative C	51,100,000	0.8:1

[a]Includes the cost of river restoration.

- The estimated construction cost for restoration of the river gradient is $3,650,000, and the local agencies are prepared for appropriate cost sharing for this facility.

Table 2
ECONOMIC EVALUATION
TOTAL PROJECT
(INCLUDING GRADIENT RESTORATION COMPONENT)

	Costs ($1,000s)				Benefits ($1,000s)						
Alternative	Capital	Annual (A/P, 8-5/8%, 50)	O&M	Total	Fishery[a]	Water Supply and Delivery[b]	Erosion Control	Pumping	Reduced Dredging	Annual Benefit	Benefit/ Cost Ratio
A (Existing)	$21,312	$1,868	$87.5	$1,956	$2,319	938 ~~$343~~	13	$77	$40	3,387 ~~$2,792~~	1.7 ~~1.42~~:1
B1 (Mouth)	30,046	2,634	112.5	2,747	2,623	938 ~~343~~	13	77	40	3,691 ~~3,096~~	1.3 ~~1.13~~:1
C (Upstream)	51,102	4,479	172.5	4,652	2,705	938 ~~343~~	13	77	40	3,773 ~~3,178~~	0.8 ~~0.68~~:1

ECONOMIC EVALUATION

GRADIENT RESTORATION COMPONENT ONLY

	Costs ($1,000s)				Benefits ($1,000s)						
	Capital	Annual (A/P, 8-5/8%, 50)	O&M	Total	Fishery[a]	Water Supply and Delivery[b]	Erosion Control	Pumping	Reduced Dredging	Annual Benefit	Benefit/ Cost Ratio
	3,650	320	25.0	345	1,187	938 ~~343~~	13	77	40	2,255 ~~1,660~~	6.5 ~~4.81~~:1

[a] These fishery benefits include the attenuation of the project fishery benefits due to the uncertainty of success in elimination of all predation above natural conditions. Should different interpretations of the predation issue be offered by the fishery agencies, Alternatives A and B benefits would change, and therefore, the B/C ratio would change. Alternative C assumed the full fishery benefit with no (0 percent) additional predation above the natural conditions.

[b] Water Supply and Delivery benefits have been corrected to agree with the text.

SOURCE: TABLE 4-10 of GCID REPORT

RDD/R77/026

TABLE 2

TABLE 2

RECOMMENDATIONS IN GCID REPORT

The GCID report makes the following recommendations:

- Restoration of the river gradient should be continued into final design.
- The cooperative efforts supported by the Technical Advisory Group and Advisory Committee should finalize the selection of the best optimal alternative for fish screen replacement/modification.
- Alternatives A, B1, and C, each of which includes river gradient restoration, should be studied further to better define fish protection benefits and construction feasibility.
- Alternative A, modification of the existing fish screens, should be reviewed in more detail. The plan, as contained in this report, assumes no benefit from the use of the existing drum screens, includes a long bypass pipeline, and results in a costly and conservative plan.

SACRAMENTO DISTRICT TECHNICAL REVIEW AND ANALYSIS

BACKGROUND AND SUMMARY

The GCID report, with final revisions, was received by Sacramento District, Corps of Engineers on December 14, 1988. The District conducted a technical review and analysis of the GCID report to determine the potential for Federal construction authorization and Federal interest in proposed GCID project alternatives. A summary of the Sacramento District comments on the GCID report are provided below.

The GCID report is in partial fulfillment of the requirements of the Department of the Army Permit (5880A), which requires identification of a long-term, state-of-the-art facility to protect fishery resources and provide for water withdrawal. GCID is responsible for developing a solution prior to obtaining any permits for work at their intake. The weir structures and the fishery protection facilities are dependent upon each other and will have to be considered as a total design package. The permit requires a combined solution to both the hydraulic and fishery problems at the GCID intake; therefore, Corps participation in the weir structure without consideration to the fishery protection will not meet the requirements of the permit. The Corps should evaluate a solution to the combined hydraulic and fishery problems at this site and ensure joint solution of these problems.

The Corps permit requires a state-of-the-art protection of the fishery resources, which would not be provided by just raising the hydraulic gradient. Raising the hydraulic gradient will improve the operation of the existing fish screen, but will not solve the loss of fish to the degree desired by public interest review. The GCID report suggests that the existing fish screens would work properly by solely modifying fish bypass inlets and water depth; however, since uneven flow velocities through the screens would still create significant problems, this aspect would need to be addressed. Additional studies are needed to determine magnitude of predation in the inlet and outlet channels and method of bypass of the fisheries.

Major project benefits include fish and wildlife enhancement and water supply. Some minor flood control benefits have been identified in the category of erosion control and savings in dredging costs. While the fish and wildlife and water supply benefits are obvious and substantial, flood control benefits will have to be evaluated according to Corps criteria. There may be adverse impacts upstream of the project area due to the potential increase in water surface elevations and groundwater levels. However, this may do nothing more than restore the upstream water

surface elevations to pre-1970 conditions. The cost estimates shown in the GCID report for the intake channel and fish screen features are insufficient in detail to allow review. However, the Sacramento District was able to review the gradient restoration feature costs.

STUDY AUTHORIZATION

Congress appropriated funds for the Corps to determine the best method to proceed with the GCID project in a Conference Report accompanying the Energy and Water Development Appropriations Act of 1989 which reads, in part, as follows:

> The Committee has been informed that as a result of the 1970 flood, the Sacramento River has been degraded from River Mile 202 to 206. This has caused operation problems for the fish screen and pump facilities at the Glenn-Colusa Irrigation District. Restoration of the original river gradient would solve this flow problem. Design work is required to determine the best method to proceed. The Glenn-Colusa Irrigation District will provide $100,000 towards the design effort. The Committee finds that the Sacramento River Flood Control Project is an appropriate authority to undertake this work. The Committee directs the Corps to initiate preconstruction engineering and design and has included $360,000 in the bill for this purpose.

DESIGN

Although the GCID report is a good report that examines the most reasonable means to control the river gradient in this river reach, further study is needed for the following: (1) bank protection cost estimates, (2) additional subsurface information to determine whether the sheet piles are of correct length and width, and (3) protection measures for the riverbed between sheet-pile weirs.

The design of the gradient restoration structure is closely tied to the engineering and design work required for the other project features (intake channel, fish screens, etc.), including special design analyses and hydraulic model studies. Due to the complex hydraulic and river mechanics, technical analyses required would include the following: (1) determine preproject flow conditions and water surface profiles, (2) determine preproject geomorphic and sediment transport conditions, (3) create a two dimensional hydrodynamic (numerical) model of the project area for determining the optimum type, location and configuration of the weir structures and intake channel features, (4) evaluate project performance over a full range of flow conditions, (5) conduct a geomorphic study of the project reach (with-project conditions), (6) address potential project-induced impacts such as higher water surface upstream, higher groundwater

tables, etc., and (7) Recognize that all the analyses (for gradient restoration, intake channel, and fish screens features) are dependent on one another.

These recommended design studies and appropriate environmental documentation are estimated to cost a total of $500,000. The design studies are as follows:

Surveys	$ 40,000
Geotechnical	60,000
Hydraulic Design	150,000
Structures	12,000
Materials/Quantities	6,000
Cost Estimating	4,000
Drafting	8,000
Economics	8,000
Environmental	40,000
Cultural Resources	2,000
Real Estate	15,000
Plans and Specs	10,000
Project Formulation	25,000
Coordination and Management	80,000
Report Preparation	40,000
TOTAL	$500,000

BENEFITS AND COSTS

General

Due to the lack of detailed technical support data, the Sacramento District could not fully substantiate or verify the cost and benefit estimates provided in the GCID report. Therefore, the numbers used for estimating costs and benefits were drawn heavily from the GCID report, and adjusted where appropriate.

Corps involvement in the project as requested by GCID would include only the gradient restoration structure on the main river. The other structures, such as the intake channel and fish screen modifications, would be the responsibility of non-Federal interests (i.e., State of California Reclamation Board and/or DF&G or GCID). All three alternatives presented in the GCID report (A, B1, and C) included the same gradient restoration structure in their design. Therefore, the costs and benefits for the gradient restoration feature of the GCID project are the same for all three alternatives.

Benefits

It appears that the gradient restoration structures would provide some erosion control benefits. The GCID report suggests that the gradient restoration structure would stabilize 340,000 cy of river sediments and assumes that 50 percent of these sediments are silts and clays that could otherwise deposit downstream, providing an erosion control or flood control benefit. The GCID report also suggests that the gradient restoration structure would reduce the deposition of 40,000 cy of sediment in the intake channel, of which 50 percent is silt and clays that would otherwise deposit downstream and incur additional dredging costs. According to preliminary Sacramento District analysis, the sediments and dredging material in the reach consist of mostly sands and gravels, and not silts or clays. This coarse material would not end up in the bypass system nor in the deep water ship channel. Therefore, it appears that the gradient restoration structure would provide minimal erosion control benefits.

In addition, the gradient restoration structure would raise the current water surface elevations upstream by 0.9 feet during high flows and 3.5 feet during low flows. The high water surface elevations could potentially increase inundation times and streambank erosion upstream. The GCID report addresses this potential problem, however, and hydraulic analysis done by WET indicates that increased upstream water surfaces are insignificant for high flows. Additional hydraulic studies of the gradient restoration structure would be required to determine the effect on bank erosion in the reach. Any adverse impacts on erosion and flood control could create negative benefits and/or incur additional costs. These cost impacts are discussed in the costs analysis.

The estimates provided in the GCID report for the commercial and recreation values for Sacramento Chinook salmon appear to be consistent with values estimated by Federal and State fishery agencies for similar purposes. In accordance with Fish and Wildlife Service comments, however, the gradient restoration structure may cause additional predation losses due to lower flow velocities upstream of the structure and creation of predator habitat in scour holes or eddies behind the structure. Fish and Wildlife Service recommendations will be obtained on the refined weir design.

The water delivery, water supply, and pumping benefits appear to be directly attributable to the gradient restoration feature of the project.

According to the GCID report, the gradient restoration structure could potentially provide the following benefits: (1) anadromous fisheries enhancement, (2) erosion control, (3) reduced dredging, (4) reduced water supply and delivery costs, and (5) reduced pumping costs. The Sacramento District believes

the gradient restoration structure would provide the following benefits: (1) reduction in loss of anadromous fisheries, (2) reduced water supply costs, and (3) flood control. The benefits are provided in Table 3.

It appears that the erosion control and reduced dredging benefits may be slightly overstated in the GCID report. However, since these flood control benefits are relatively small compared to the fishery enhancement and water supply benefits, any likely change in these benefits would have little impact on the overall project economic justification.

Costs

The cost estimates provided in the GCID report for the gradient restoration structure and annual operation and maintenance costs are limited in detail, and require further analysis. The basic design of the structure, including the length and width of the sheet piles need to be confirmed. More extensive bank protection work may be required to prevent the river from eroding around the structure. Any improvements to the design of the structure and project mitigation measures may increase the cost of the project. Although more refined studies are required, the cost estimates in the GCID report appear reasonable for this stage of project development. After adding overhead, contingencies, engineering and design, supervision and administration, and other costs, the cost of the structure is estimated at $5,530,000. The total project costs for all three alternatives are shown in Table 3. A slight increase in annual costs over GCID estimates occurs when an interest rate of 8-7/8 percent (rather than 8-5/8 percent) is used.

Economic Justification

Based on the data for the total project (which includes all features) shown in Table 3, Alternatives A and B1 appear to be economically justified, and Alternative C appears to be marginally infeasible.

DISCUSSION

Federal and USACE Interest

There is a nationally recognized, severe fisheries problem in this reach of the Sacramento River, amounting to a loss of as many as 6.5 million juvenile salmon a year. Numerous Federal laws recognize the national responsibility for the protection of anadromous fisheries. Furthermore, the Corps has recognized a Federal interest and concern for this fisheries problem at the GCID intake channel through the Sections 10 and 404 permitting process. USACE interest in fisheries problems on the Sacramento River are demonstrated by 1) the Letter of Intent signed 1 NOV 88

TABLE 3*
SACRAMENTO DISTRICT ASSESSMENT OF
BENEFIT/COST RATIOS FOR TOTAL PROJECT
(50 Year Project Life, 8-7/8 %)

	Costs ($1,000s)				Benefits ($1,000s)				
Alternative	Capital	Annual (A/P, 8.875%, 50)	O & M	Total Cost	Fisheries Losses Reduction	Water Supply	Flood Control	Annual Benefit	Benefit/Cost Ratio
A (Existing)	23,192	2,088	87.5	2,176	2319	1015	53	3387	1.6
B1 (Mouth)	31,926	2,875	112.5	2,988	2623	1015	53	3691	1.2
C (Upstream)	52,982	4,770	172.5	4,943	2705	1015	53	3773	.8

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* Modified from Table 2 (Table 4-10 of GCID report)

between the National Marine Fisheries Service and the Corps for developing procedures and criteria for protecting winter-run salmon and 2) salmon habitat mitigation measures implemented for past construction on Phase I of the Sacramento River Bank Protection Project. The proposed gradient restoration feature of the GCID project is primarily in the interest of reducing damages to the anadromous fisheries occasioned by operation of the GCID facility, and is economically justified.

Based on the analysis of benefits and costs for the gradient restoration feature of the project and total project, three benefits were identified: (1) reduction in loss of anadromous fisheries, (2) water supply, and (3) flood control. The flood control benefits, however, are small. Reduction in anadromous fisheries losses provide the majority of benefits. Cost and benefit estimates provided in the GCID report appear to be reasonable. The gradient restoration feature of the project is estimated by the Sacramento District to cost $5,530,000. Alternatives A and B1 appear to be economically feasible.

USACE Authority

o The GCID project could be considered for implementation under Section 1135 of the Water Resources Development Act of 1986 (WRDA 86). This section could be applied to the existing Sacramento River, Chico Landing to Red Bluff Project. Section 1135(a) reads as follows:

> The Secretary is authorized to review the operation of water resources projects constructed by the Secretary before the date of enactment of this Act to determine the need for modifications in the structures and operations of such projects for the purpose of improving the quality of the environment in the public interest.

The Sacramento District previously submitted the GCID fisheries problem as a Proposal for Demonstration Project under Section 1135(b) of WRDA 86. However, this proposal was denied approval. Section 1135(b) reads, in part, as follows:

> The Secretary is authorized to carry out a demonstration program...for the purpose of making such modifications in the structures and operations of water resources projects ...which the Secretary determines 1) are feasible and consistent with the authorized project purposes, and 2) will improve the quality of the environment in the public interest.

Congress has continually refused to fund this type of project.

o The GCID project could also be considered for implementation under Section 704(b) of the Water Resources Development Act of 1986, which reads, in part, as follows:

> The Secretary is further authorized to conduct projects of alternative or benefically modified habitats for fish and wildlife, including but not limited to man-made reefs for fish.

Current Corps policy views this as a one-time authorization for the four projects listed in Section 704.

o Further, USACE authorization for construction of the gradient restoration feature of the GCID project could be considered under an existing Sacramento River project authority. However, anadromous fisheries benefits are not included in any of the Sacramento River authorized projects. These projects include:

Flood Control
- o Sacramento River Flood Control Project
- o Sacramento River, Chico Landing to Red Bluff Project
- o Sacramento River Bank Protection Project
- o Sacramento River and Major and Minor Tributaries

Navigation
- o Sacramento River, Shallow Draft Channel.

If the gradient restoration feature is constructed under one of the existing projects, fish and wildlife enhancement would have to be added as a project purpose to the original authorization. Guidelines for approval of changes to uncompleted authorized projects are given in ER 1105-2-10, Chapter 2 and Appendix A. The addition of fish and wildlife enhancement not specifically authorized as a project purpose can be recommended by Division commanders for HQUSACE approval if any lands that need to be acquired are voluntarily provided by a non-Federal entity (ER 1105-2-10, Appendix A, Section III, A-9b).

In summary, the Sacramento District has identified potential authorities for USACE development of the gradient restoration feature. These potential USACE authorities and their implementation problems are summarized below:

o Section 1135(b) of WRDA 86, as amended, on the basis that the gradient restoration feature is a modification of an existing project (Sacramento River, Chico Landing to Red Bluff Project) to improve the quality of the environment in the public interest through fish and wildlife enhancement. However, a previous SPK application was denied, and Congress has continually refused to fund this type of project.

o Section 704(b) of WRDA 86 on the basis that the project is a beneficial modification of habitat for fish and wildlife. However, current Corps policy views this as a one-time authorization for the four projects listed in this section of WRDA 86.

o Add a project purpose for fish and wildlife enhancement to an existing project. However, a two-fold policy decision would be required, including determination of enhancement as opposed to mitigation, and determination of appropriateness of action.

A final alternative is the "no action" alternative. This would be the result of a determination that there is no USACE interest or authority for the project. If this is determined, GCID would still be required to comply with the conditions of the Corps Permit. If GCID is not able to meet the conditions of the Corps Permit, the Corps would likely not reissue the Permit. In this situation, GCID could not continue to obtain all of their water needs from the existing facilities and would need to find alternative water sources, although a considerable amount of diversion would still continue with continuing fishery losses. GCID could also find another location and method of diverting and pumping water without affecting the Sacramento River fishery, or GCID could build the gradient restoration feature of the project themselves.

A matrix on potential authorities for USACE involvement in the project is shown in Table 4.

TABLE 4
POTENTIAL AUTHORITIES MATRIX

	1. SEC 1135(b) WRDA 86	2. SEC 704(b) WRDA 86	3. ADD PROJECT PURPOSE	4. NO CORPS INTEREST
DECISION MAKER	ASA(CW)	ASA(CW)	USACE	USACE
REGULATORY ACTION	Extend Interim Permit To Meet Corps Schedule (Assuming Decision Is Made Before NOV 89)			Enforce Permit Cond's
COMMENTS	Previous SPK app. denied. Congress has not funded.	Limited to the 4 projects listed in Sec 704 of WRDA 86	Policy decision required	Local interests responsi-bility

CONCLUSIONS

- A serious anadromous fishery problem exists on the Sacramento River near River Mile 206.
- There is both a Federal and a USACE interest in the solution of the fishery problem through the Sections 10 and 404 permitting process.
- An economically feasible project has been identified to solve the problem.
- Based on existing authorities and programs, there is no Corps of Engineers authorization for the restoration of the Sacramento River streambed gradient near River Mile 206, primarily for anadromous fisheries loss reduction.
- The preparation of a detailed design document is estimated to cost $500,000 and would extend over a period of 20 months.

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22 October 2008

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The enclosed documents from USACE Sacramento District are hereby submitted for inclusion in DTIC's technical reports database. The following is a list of documents included in this shipment:

ADB344304 • Lemon Reservoir Florida River, Colorado. Report on reservoir regulation for flood control, July 1974

ADB344333 • Reconnaissance report Sacramento Metropolitan Area, California, February 1989

ADB344346 • New Hogan Dam and Lake, Calaveras River, California. Water Control Manual Appendix III to Master Water Control Manual San Joaquin River Basin, California, July 1983

ADB344307 • Special Flood Hazard Study Nephi, Utah, November 1998 (cataloged)

ADB344344 • Special Study on the Lower American River, California, Prepared for US Bureau of Reclamation – Mid Pacific Region and California Dept. of Water Resources..., March 1987

ADB344313 • Transcript of public meeting Caliente Creek stream group investigation, California, held by, the Kern County Water Agency in Lamont, California, 9 July 1979

ADB344302 • Initial appraisal Sacramento River Flood control project (Glenn-Colusa), California, 10 February 1989

ADB344485 • Report on November-December 1950 floods Sacramento-San Joaquin river basins, California and Truckee, Carson, and Walker rivers, California and Nevada, March 1951

ADB344268 • Reexamination Little Dell Lake, Utah, February 1984

ADB344197 • Special report fish and wildlife plan Sacramento River bank protection project, California, first phase, July 1979

ADB344264 • Programmatic environmental impact statement/environmental impact report Sacramento River flood control system evaluation, phases II-V, May 1992

ADB344201 • Hydrology office report Kern river, California, January 1979

ADB344198 • Kern River – California aqueduct intertie, Kern county, California, environmental statement, February 1974

ADB344213 • Sacramento river Chico Landing to Red Bluff, California, bank protection project, final environmental statement, January 1975

ADB344265 • Cottonwood Creek, California, Information brochure on selected project plan, June 1982

ADB344261 • Sacramento river flood control project Colusa Trough Drainage Canal, California, office report, March 1993

ADB344343 • Detailed project report on Kern River-California aqueduct intertie, Kern County, California. February 1974

ADB344267 • Sacramento River Flood Control Project, California, Right Bank Yolo Bypass and Left Bank Cache Slough near Junction Yolo Bypass and Cache Slough, Levee construction, General Design, Supplement No. 1 to Design Memorandum #13, May 1986

ADB344246 • Redbank and Fancher Creeks, California, General Design Memorandum #1, February 1986

ADB344260 • Cache Creek Basin, California, Feasibility report and environmental statement for water resources development Lake and Yolo counties, California, February 1979

ADB344199 • Sacramento River Deep Water Ship channel, California, Feasibility report and environmental impact statement for navigation and related purposes, July 1980

ADB344263 • Sacramento River flood control project, California, Mid-Valley area, phase III, Design Memorandum, Vol. I or II, June 1986

ADB344262 • Marysville Lake, Yuba River, California, General Design Memorandum Phase I, Plan Formulation, Preliminary Report, Appendixes A-N, Design Memorandum #3, March 1977

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